LA-MC-ICP-MS U-Pb Zircon Geochronology of the Lan Sang and Nong Yai Gneisses, Thailand

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ABSTRACT

The Lan Sang and Chon Buri gneisses are dominated by NW-SE trends within the different parts of Thailand. The Lan Sang Gneiss, associated with the Mae Ping fault zone, is found in northern Thailand while the Nong Yai Gneiss is limited within the Klaeng fault zone in the eastern part. Both strike-slip systems are characterized by the sinistral ductile movement under high metamorphic conditions. Our preliminary LA-MC-ICP-MS U-Pb zircon dating suggests that the metamorphic event found in the Lan Sang Gneiss has taken place in the Triassic, and the Nong Yai Gneiss was in the Cretaceous. These data suggest the different evolutionary periods of the NW-SE strike-slip systems in Thailand.

Keywords: LA-MC-ICP-MS U-Pb Zircon Dating, Lan Sang Gneiss, Nong Yai Gneiss, Thailand

1. INTRODUCTION

High grade metamorphic rocks in Thailand were originally interpreted as Precambrian in age (Salyapongse, 2002). They generally extend in a north-south direction with an elongated shape. Two gneissic rocks expose as a NW-SE trends within prominent NW-SE continental-scale strike-slip systems (Figure 1). The first occurrence, the Lang Sang Gneiss, is located within the Mae Ping fault zone or Wang Chao fault zone (Lacassin et al., 1993, 1997) in northern Thailand. The Nong Yai Gneiss extends to the Klaeng fault zone in eastern Thailand. Some regional geological interpretations connect the Mae Ping fault zone to the Klaeng fault zone (Lacaaasin et al., 1993, 1997). Others interpretations extend the Mae Ping fault zone to Maekhong Delta and connect the Klaeng fault zone to the Three Pagoda fault zone (Charusiri et al., 2002; Morley, 2002). The ages of the gneissic rocks that are related to the strike-slip zones are poorly constrained. Therefore, the geochronology data is evidently important to improve the understanding for the geologic evolution of these areas.

In this paper we present new U-Pb laser ablation-multicollector-inductively coupled plasma mass spectrometer (LA-MC-ICP-MS) geochronological data of the Lan Sang and Nong Yai gneisses to constrain the timing of their metamorphism. We use this new data to compare these with the published evolution models of the NW-SE strike-slip systems in Thailand.

2. GEOLOGICAL SETTING

The Lang Sang Gneiss is exposed along the Lan Sang national park within the Mae Ping fault zone. The local geology is dominated by mylonited greenschist facies gneisses of approximately 5 km width (Lacassin et al., 1993). The rocks consist of paragneiss and orthogneiss with steep foliations and nearly horizontal stretching lineations (Lacassin et al., 1993, 1997). The sinistral shear indicators such as S-C fabrics (Figure 2a, b) are presented all along the Lang Sang Gneiss outcrops.

The Mae Ping fault zone first developed during a transpressional event in the Late Cretaceous to Early Cenozoic (Morley, 2004). Ar^{40}/Ar^{39} mica dating shows that the ductile left-lateral shear terminated around 30.5 Ma and suffered rapid cooling around 23 Ma in the Tertiary (Lacassin et al., 1997). The minimum shear of the shear zone was 7±4 with 35±20 km displacement based on boudinage restoration (Lacassin et al., 1993). Previous cooling ages plus apatite and zircon fission-track dating indicates that the exhumation of the Lan Sang area can be either part of a regional Late Oligocene to Early Miocene north-south trending event or a composite of strike-slip related deformation superimposed on a north-south striking regional trend (Morley et al.,2007)

In contrast to the Lan Sang Gneiss, which seems to be made of reworked greenschist-facies rocks, the Nong Yai Gneiss (Khao Chao Gneiss) was metamorphosed from amphibolite facies (Areesiri, 1983) to upper-amphibolite to granulite facies (Kawakami et al., 2008). The outcrops are well exposed at Amphoe Nong Yai, Changwat Chon Buri. The metamorphic rocks consist of paragneiss, amphibolite and migmatite gneiss succession (Areesiri, 1983). The Nong Yai Gneiss can be divided into 6 units which are biotite feldsparthic quartz gneiss (Figure 2c), biotite hornblende gneiss, biotite gneiss, hornblende diopside gneiss, biotite sillimanite gneiss, and biotite diopside gneiss (Areesiri, 1983). Various shear criteria are consistent and indicate sinistral shear sense such as σ-shaped feldspar (Figure 2d).

The P-T condition of the Nong Yai Gneiss is estimated to be ~730°C and 7.0 kbar to ~840°C and 9.5 kbar for the metamorphic peak and 580°C and 5.0 kbar to ~700°C and 7.1 kbar for the retrograde re-equlibrium stage (Kawakami et al., 2008). Rb/Sr dating gave 75±22 Ma of foliated quigranular granite within the gneisses

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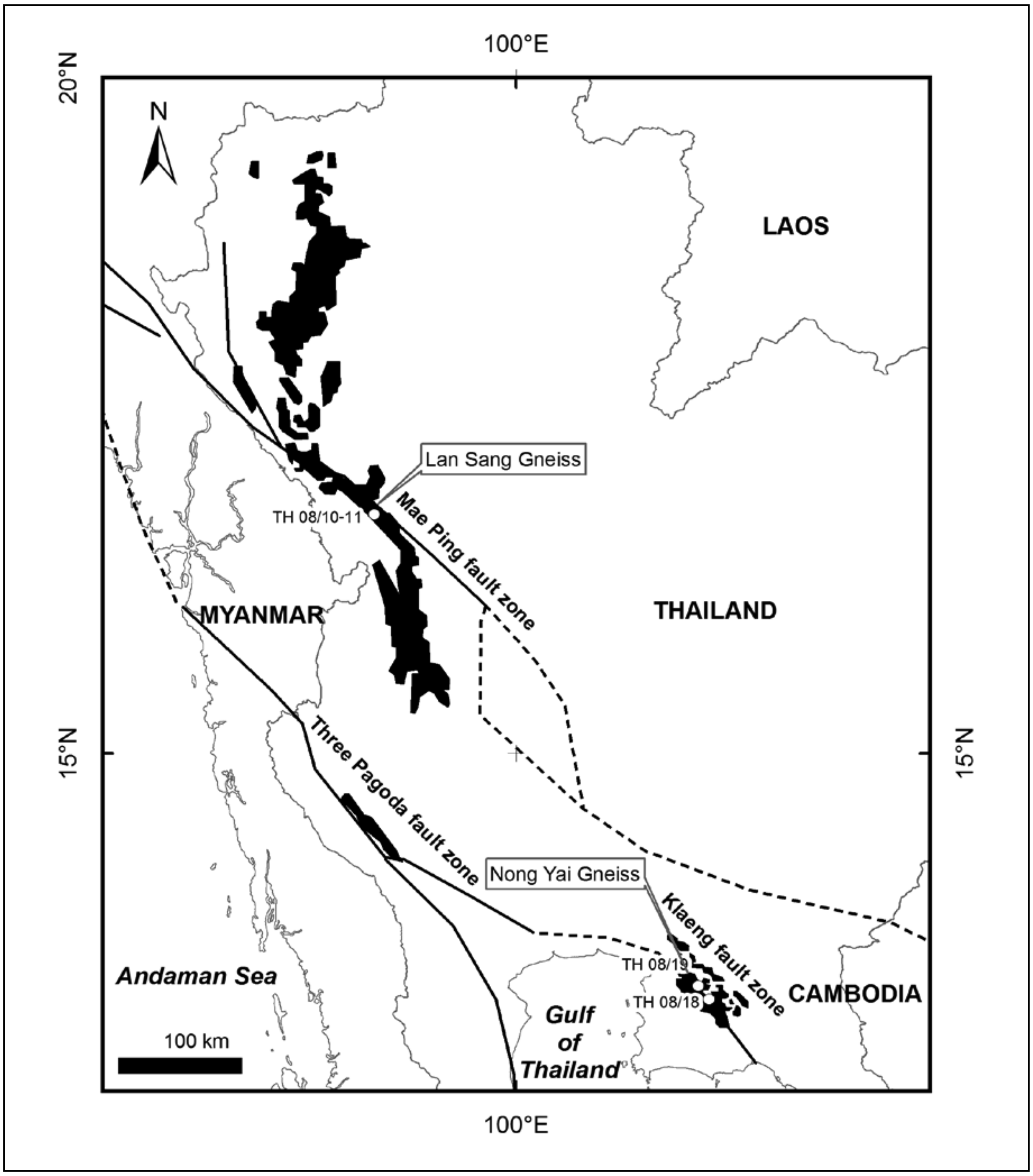

Figure 1. Inferred Precambrian metamorphic rock along the major strike-slip zones in Thailand; white dots, sample location (modified from Salyapongse, 2002).

(Darbyshire, 1988). Buckle folding occurred together with the first metamorphism in Late Caboniferous (Areesiri, 1983). Two shear episodes and the second metamorphism took place in Permo-Triassic (Areesiri, 1983).

3. LA-MC-ICP-MS U-Pb ZIRCON GEOCHRONOLOGY

Two samples of each the Lang Sang Gneiss and Nong Yai Gneiss, respectively were taken for LA-MC-ICP-MS U-Pb zircon dating. Zircons were separated using standard grain sized, gravity and magnetic separation techniques. Representative gains were extracted by hand-picking under a binocular microscope. Zircons were mounted in an epoxy mount before polished to reveal mid-sections. All zircons were analyzed by cathodoluminescence (CL) images to identify their internal structures and select areas for analysis. Zircon LA-MC-ICP-MS U-Pb dating was analyzed at Geochronology Laboratory, University of Vienna. For details of U-Pb isotope ratios measurement using LA-MC-ICP-MS see Klötzli et al. (2009).

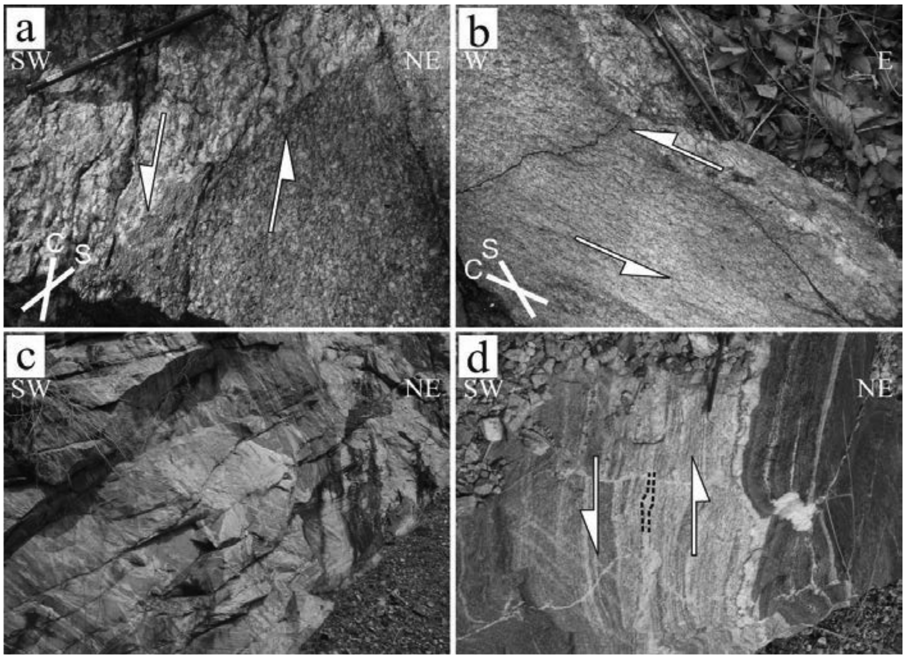

Figure 2. Outcrop of the gneisses. a) and b) The Lan Sang Gneiss shows sinistral S-C fabric. c) and d) The Nong Yai Gneiss shows the sinistral σ-shaped feldspar.

3.1 The Lan Sang Gniess

Lan Sang Gneiss is represented by samples TH08/10 and TH08/11 (Figure 2a, b). The majority of the Lang Sang Gneiss zircon grains are around 200 μm in length. They have euhedral to subhedral shape with well-developed concentric oscillatory zoning. Relict cores of zircons are overgrown by metamorphic rims. Two analyses were conducted on two zircons for sample TH08/10 and twelve analyses were conducted on ten zircon grains for sample TH08/11. The analyses on the metamorphic rims give a concordia age of 191±10 Ma (TH08/10) and 206±4.0 Ma (TH08/11), respectively (Table 1).

3.2 The Nong Yai Gneiss

Sample TH08/18 and TH08/19 were investigated for the Lan Sang Gneiss (Figure 2c, d). Both samples contain predominantly elongate zircon grains. Zircons are euhedral to subhedral in shape, ranging in length from 300 to 500 μm. All zircons are concentrically zoned with relict cores in CL images, indicating metamorphic rim overgrowth. Two analyses were conducted on two separate zircon grains for sample TH08/18 and eight analyses were conducted on five zircons for sample TH08/19. These analyses on the rim yield a concordia age of 67±3 Ma (TH08/18) and 75.4±0.4 Ma (TH08/19) (Table 1).

Table 1. U-Pb zircon age of the Lan Sang Gneiss and Nong Yai Gneiss.

Sample	Rock units	U-Pb ages (Ma)
TH08/10	Lan Sang Gneiss	191±10
TH08/11	Lan Sang Gneiss	206±4
TH08/18	Nong Yai Gneiss	67±3
TH08/19	Nong Yai Gneiss	75.4±0.4

4. DISCUSSION

The U-Pb isotope system in zircon gives the closure temperature ≥800 °C (Tilton et al., 1991) and give ages close to the deformation age of shearing under high temperature condition.

The LA-MC-ICP-MS U-Pb ages of the growth rims of zircons obtain from the gneisses at Lan Sang and Nong Yai are of particular significant. The ages of 191±10 and 206±4 Ma are interpreted to be the best estimate of the timing of high temperature metamorphism during the sinistral shear of the Mae Ping fault movement. We interpret the ages of 67±3 and 75.4±0.4 Ma as the timing of high temperature metamorphism during the sinistral movement of the Klaeng fault zone.

5. CONCLUSION

Both Lan Sang and Nong Yai gneisses exhibit well preserved high-temperature sinistral shear deformation of the NW-SE Mae Ping and Klaeng fault zones. LA-MC-ICP-MS U-Pb zircon dating reveals two different tectono-thermal events. The first one occurred with the sinistral shear of the Mae Ping fault zone at the time span of 191 to 206 Ma, which is interpreted to be associated with Shan-Thai and Indochina microcontinent collision in the Permo-Triassic in Thailand (Charusiri et al., 2002). The second tectono-thermal event developed in an age range around 67 to 75 Ma, which is thought to be related to sinistral shearing of the Klaeng fault zone during the Cretaceous extrusion tectonic event in Southeast Asia (Tapponnier et al., 1982; Charusiri et al., 2002).

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